OBSERVATIONS ON HISTORICAL CHANGE IN RAINFALL, HYDROLOGY, FOREST STRUCTURE, VEGETATION AND ECOSYSTEM HEALTH (1880-2022). NORTHERN JARRAH (E.marginata) FOREST, WESTERN AUSTRALIA.

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INTRODUCTION

I have produced this document from peer-reviewed literature, Departmental and Consultant's reports, historical records and word-of-mouth, as well as my own research and observations over 60 years.

My expertise and observations apply only to the northern jarrah and wandoo forest between Mundaring and Collie. The southern jarrah and karri forests have higher rainfall, lower evapo-transpiration and pockets of soils with higher fertility and should be better able to cope with drought. Others have an extensive knowledge of these southern forests.

I am well aware that the data and hypothesis presented here will challenge the current thinking about climate change and likely future impacts. The jarrah forest and woodlands have now been identified as one of Australia's ecosystems at risk of collapse. A recent IPCC report "Fact sheet on Australasia, climate change impacts and risks" has also listed the northern jarrah forest as "a key risk of transition or collapse (high level of confidence). However I believe that these positions were based on an incomplete data set and without the benefit of visiting the forest and discussions with experts in forest management.

The role of Science is to keep testing current thinking, based on sound data.

RAINFALL Data from 1880 at rainfall stations located at Perth airport and at Jarrahdale show a cyclical dry-wet-dry cycle between 1880-1914, 1915-1965 and from 1965. Rainfall averages for these periods are as follows: Perth: 735mm, 862mm and 776mm and Jarrahdale: 1100mm, 1251mm and 1054mm. I am aware that rainfall data at Waroona and Albany has shown similar trends. Very high rainfall years were: 1915, 1917, 1945, 1946, 1963, 1964 and 1967. Tree ring studies indicate that the first half of the twentieth Century was unusually wet and that a "drier climate" is probably the normal situation for these forests.

WATERTABLES Since the 1960's, with less rain, watertables have fallen many metres in both the Swan Coastal plain and in the forest. I have been unable to find any data on borelevels in the forest prior to the 1960's. It is reasonable to expect that, as rainfall increased over many decades, watertables also rose considerably. There are simulations based on rainfall that indicate a rise of about three metres in the Gnangara Groundwater mound (1914 to 1968) and then a similar fall from 1968-2004. It should also be possible to use rainfall records for Jarrahdale to estimate the increase in watertable in the jarrah forest from 1880 to 1965. Computer modelling for 31 Mile brook shows that pressure-head of watertables in gully- heads were some metres above ground in the mid 1960's, but are now well below the soil surface. A waterpoint, built in the 1950's adjacent to 31 Mile brook is now a puddle, even by the end of winter.

STREAMFLOW When watertables are close to or intersect the soil surface, the "wetted area" is larger and streamflow rises dramatically. Presumably streamflow would have increased substantially between 1915 and 1965 as the result of increased rainfall and raised watertables. Years with exceptional flow (more than twice the mean value) include 1917, 1926, 1945, 1946, 1954, 1963 and 1964. Conversely, as rainfall and watertables fell there has been an estimated reduction of about 75 percent in flows into the surface catchment reservoirs since 1965. CSIRO data show increasing flows into the Metropolitan Water Supply System from 1940, peaking in 1975 and then falling to 2000. Reduced volume and more importantly number of flow days will impact aquatic biodiversity. Species with longer life cycles may no longer be able to breed, as shown by studies in 31 Mile brook. Wildfire is also a major threat to water quality and aquatic biodiversity, as shown by the 2005 "Hills wildfire'.

WATER STORAGES In the early 1900's the recently built Mundaring Weir was filling so slowly that the Public Works Department ring-barked 5000 hectares of forest to improve inflows. In contrast, the key water storages for Perth (Canning, Serpentine, North and South Dandalup and Wungong) were built between 1940 and 1994, after decades with higher rainfall and flow. Occasionally Canning dam used to overflow and attract many visitors and in 1964 the town of Harvey was evacuated when the Harvey Weir threaten to collapse as a result of two consecutive years with exceptional rainfall. Recent storage levels have been extremely low. South Dandalup dam built in 1971, has the largest storage volume, but a relatively small catchment that extends well into the lower rainfall zone and has never come close to filling. The Water Corporation has publicly abandoned its reliance on surface water catchments.

WATERLOGGING Consistently higher watertables led to waterlogging especially in gully-head sites, contributing (in conjunction with P cinnamomi) to the death of susceptible species (such as jarrah) and invasion of some of these sites by wetland species (such as yarri, bullich and Hypocalymna). There are anecdotal reports of forest workmen planting pine in waterlogged dieback sites, working calf-deep in mud. Improved moisture relations may also have encouraged jarrah and banksia to invade shallower soils closer to rock surfaces. In the drier eastern forests watertables remained well below the surface and waterlogging was less prevalent.

PHYTOPHTHORA DISEASE Phytophthora disease and waterlogging combined to devastate large areas of the forest, especially on water-gaining sites in the higher-rainfall zone, killing jarrah, banksia and a suite of understorey and shrub species. Concerns about the impacts of "jarrah dieback" were first expressed in the 1940's, following two years of exceptionally high rainfall in 1945 and 1946. Mapping from aerial photos in the 1960's indicated that 10-20 percent of the western, high rainfall forest had been impacted. Most of these areas have been rehabilitated or have regenerated naturally. Recent deaths in the jarrah forest attributable to Phytophthora disease are now much less obvious, in part because the susceptible sites have already been affected.

DROUGHT In recent years the environmental concerns have not been about waterlogging and Phytophthora but rather an occasional but widespread crown scorch, and some tree deaths, predominantly on shallow soils near rock surfaces, rehabilitated bauxite pits and in some gully-head sites. These episotic events are linked to dry winters and hotter summers. A survey of the 2011 drought in the northern jarrah forest by Academics from Murdoch University, reported that about 1.5 percent (1350 ha) of the survey area (90000 ha) was impacted, with 25 percent tree deaths within the affected areas. By 2018 the level of mortality within affected sites had risen to 40 percent. This event affected only an extremely small part of the forest, it was restricted to shallow soils less suited to tree growth and 60 percent of the stems on the affected sites have reduced leaf cover but have survived.

While this event is of some concern, it is hardly the “catastrophe” described by Bergstrom et al in 2021 as follows “ an extreme heatwave in 2010-2011 ravaged land ecosystems and devastated forests and woodlands in Western Australia”. This description does not fit either with the published data or subsequent field surveys. Some Academics are happy to comment on areas where they have no expertise or local knowledge. In contrast, the views of locals with years of practical management experience are mostly ignored.

VEGETATION A mature forest fully uses the site and there is intense competition for key resources, such as nutrients and water. Change is constant, it may be subtle, such as an old-growth tree dying and being replaced, or obvious, such as a post-fire succession. Fortunately, for the jarrah forest, we are able to examine vegetation change over time in a regrowth stand. In 31 Mile Brook 480 detailed vegetation plots, originally measured in 1972/73 were remeasured in 2012. Over this 40 year period there were major reductions in rainfall, in groundwater, in streamflow and in aquatic biodiversity in this catchment. Changes in vegetation were more subtle, some tree deaths close to rock surfaces and a slight “xeric” shift in gully-head sites for species (yarri, bullich and Hypocalymna) that favour a wetter habitat. Reconnaissance surveys in 2020 and 2021 indicate that change is still minor. Over 50 years, the vegetation has shown remarkable resilience to major changes in hydrology.

CSIRO data from 31 Mile Brook (2006 to 2011, based on an index derived from Landsat data) show that leaf area can fluctuate violently from year to year dependant on antecedent rainfall. There were falls of over 20 % in 2007 and 2011 following two dry years and an increase of nearly 70% in the intervening three years with reasonable rainfall. Interestingly, after such dramatic annual changes the LAI values for 2006 and 2011 were the same (1.1). Given these dynamic changes from year to year, the observed changes in cover of less than 5 % between decades , as shown in the “end of term performance report on the Forest Management Plan 2013-2024”, I would regards as insignificant.

Near White Gum road a patch of bullich of about one hectare collapsed in late summer 2011, and was re-assed nine years later. The partial recovery confirms that drought was the most probable cause of the original deaths. The drought killed most of the larger trees, allowing coppice stems and seedlings to dominate. This new stand will be much more susceptible to fire damage as the crowns are lower, the bark is thinner and there is less seed in the young crowns. The site has not been burnt for at least 15 years and carries high fuel load. Bullich wetlands are key areas for the conservation of a range of threatened mammal and bird species. Many valuable bullich wetlands were incinerated in the Yarloop fire. Wildfire, such as occurred in the Mt Cook area, is also a significant threat to the important heathland communities located near and on exposed rock surfaces.

The jarrah forest covers an East-West range of about 50 kilometres that spans a wide range of rainfall. The forest adjusts, it is shorter, has a lower basal area, trees are more widely spaced, crown cover is less and there are changes in the composition of understorey species. Site-vegetation types that cover the full range of rainfall have been documented and mapped, providing an opportunity to reasonably predict the direction and extent of any future change. The ability of jarrah to grow and be healthy in low rainfall should give confidence that this ecosystem will continue to show resilience and survive, even if rainfall is to decline further, as current modelling suggests.

The forest structure is now is very different to that of the 1850's, with potential to transpire at a much higher rate. Change includes extensive and multiple timber harvesting operations and regeneration, substantial areas have had silvicultural treatment (such as timber stand improvement or thinning), mining for bauxite and rehabilitation, Phytophthora disease and rehabilitation as well as altered fire regimes. Most of the timber harvesting in the higher rainfall forest occurred before 1920, with minimal control by Government. Old-growth trees were large, more widely spaced, slower growing, with secondary crowns and with a sparser understorey, probably as the result of frequent, milder fire managed by the indigenous inhabitants. These stands were replaced with more closely spaced regrowth, with primary crowns, faster growth, a larger cambial area and a denser understorey which developed when fire intervals became longer. These stands can transpire at about twice the rate of older trees. However evapotranspiration rates can be regulated by closing stomata, and, in an extreme situation, by substantial shedding of leaves and branches, as was observed in summer 2011. 31 Mile brook catchment has been harvested for timber and regenerated on three occasions. Most of the regrowth is about 70 years old.

BASELINES Most of the research into hydrology, Phytophthora and the forest ecosystem has been done in the past 70 years, following decades with above-average rainfall. These data have measured "only the receding tide" and need to be interpreted with great care, preferably by also considering historical records of rainfall and hydrology to 1880.

ECOLOGICAL THINNING Ecological thinning will reduce competition for water and nutrients and improve resistance to drought in the retained stems. Watertables will rise (especially the shallow, perched watertable) and streamflow should increase. Monitoring (2008 to 2020) shows that thinning will not raise jarrah's susceptibility to Phytophthora disease. Due to cost, operational constraints and public concern, ecological thinning is unlikely to be implemented at a landscape scale. Sites such as the Geocrinia wetlands near Margaret river and smaller streams with threatened aquatic fauna should be given priority. As a result, most of the forest covered by this FMP will need to be resilient and survive for the next ten years without the benefit of thinning.

EXTERNAL INFLUENCES

The peer-reviewed work by on the 2011 drought by the Murdoch academics has been cited in an International review on forest health as an example of an "unprecedented, climate change induced dieback and drought event". A workshop in 2020 selected the northern jarrah forest as one of the Australian ecosystems "at risk of collapse" (defined as-a change from a baseline state beyond the point where an ecosystem has lost key defining features and functions). In my view, the loss of some trees on shallow soils, covering less than 1.5 percent of the forest, clearly does NOT fit this definition. A more appropriate position would have been " an ecosystem where further investigation is warranted'.

While this drought event in 2011 was initially of some concern to me, it is hardly the "catastrophe" then described by Bergstrom et al in 2021 (the lead author of the 2020 workshop report, an academic at the University of Wollongong) as follows " an extreme heatwave in 2010-2011 has ravaged land ecosystems and devastated forests and woodlands in Western Australia". This description is emotive, highly unscientific and does not fit either with the published data, local knowledge or subsequent field surveys. You only need to take a casual drive into the forest to see that the "ravaging and devastation" has not occurred.

The workshop report was then used by the IPCC, who produced their 6th assessment report, fact sheet on Australasia, climate change impacts and risks. The northern jarrah forest is now listed a "key risk of transition or collapse (high level of confidence)". I believe that all of these statements were based on an incomplete data set, without the benefit of visiting the forest and discussions with experts in forest management.

CONCLUSIONS Substantial changes in hydrology, fire intervals, forest structure and ecology have occurred in the jarrah forest over the past 150 years and change will continue to occur. The data indicate that the drier phase that we are in now is probably the "normal" condition for this forest. Excessive rainfall, waterlogging and Phytophthora disease combined have had a much greater ecological impact on the forest than the more recent drought events. Wildfire in key habitats, such as bullich wetlands, streamzones and rock outcrops, has also been more extensive and ecologically damaging than drought. Enhanced protection measures for these habitats will be required in a drying climate.

The forest covered by this FMP will need to survive for the next ten years without the benefit of broad-scale ecological thinning. Some scientists and the IPCC report confidently predict a "catastrophe", a "devastation of the forests and woodlands in Western Australia" and that "climate change induced dieback, drought, transition and collapse" will occur. In contrast, my view is that this forest has already shown resilience to drought, despite a major decline in rainfall, streamflow and groundwater. The ability of jarrah forest to grow in lower rainfall supports my hypothesis that it will continue to show resilience and survive as a functioning ecosystem, even if rainfall is to decline further, as current modelling suggests. This prognosis should be received as "good news" for the upcoming FMP draft.

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